Science 10

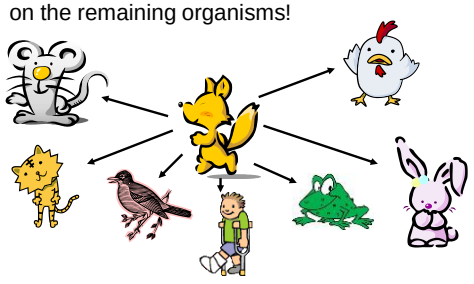
Sustainable Ecosystems

What is an Ecosystem?

- Ecosystem- Relationship among many species and the environment surrounding them.
  - Includes all living (biotic) and non-living (abiotic) things.
    - Abiotic things include sunlight, temperature, wind, water, rocks, etc.
- Everything in an ecosystem is related.
  - What affects one thing will affect another

- The more species there are in an ecosystem, the more stable the ecosystem is.
  - Each organism is less dependant on the next organism.
- The number of different species in an ecosystem is called biodiversity.

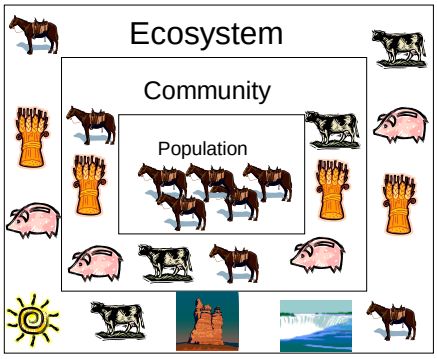
- As biodiversity decreases, more pressure is put on the remaining organisms!



- We keep track of organisms through a classification system for at risk species:
  - Vulnerable: species at risk because of low or declining numbers at the fringe of its area.
  - Threatened: species that is likely to become endangered if factors that make it vulnerable are not reversed.
  - Extirpated: species that no longer exists in one part of Canada but can still be found in others.
  - Endangered: species that is close to extinction in all parts of Canada or a significantly large location.
  - Extinct: species that is no longer found anywhere

Ecology

- Ecology- the study of where one lives.
- In our ecosystem we will find:
  - Populations: all the members of the same species living in the same ecosystem.
  - Communities: collection of all the populations of all species in an ecosystem (Same as ecosystem without the abiotic factors)



Classifying organisms in the ecosystem

- Producer- organism that produces its own food (energy) (usually from sunlight).

- Consumer- organism that consumes other organisms for food (energy). (Herbivores, Carnivores, Omnivores)

- Herbivore- Organism that eats plants (producers)

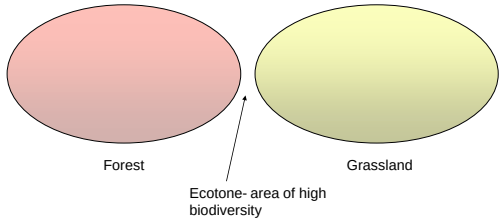
- Carnivore- Organism that eats flesh (consumers)

- Omnivore- Organism that eats both plants and flesh.

- Decomposer- organism that consumes previously dead organisms.

Ecotones

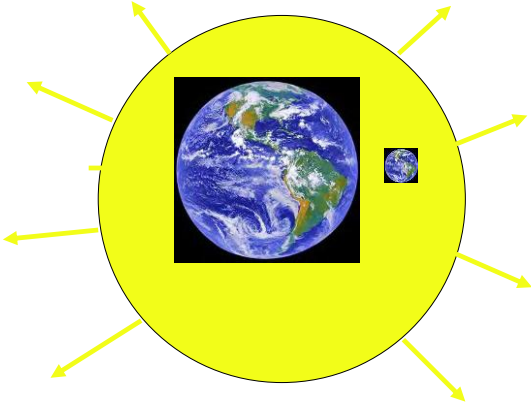
- Ecotone- transition area between two ecosystems.

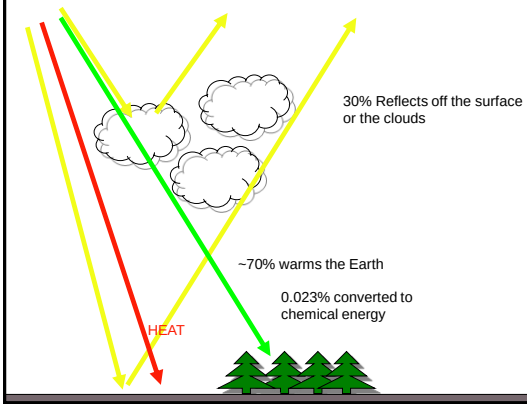


Energy in the Ecosystem

- All energy on Earth comes from the Sun.
  - The Sun's energy is not useable by most organisms.
- Plants are able to convert the Sun's energy into chemical energy (sugar) that can be used and passed on by other organisms.

- Not all the Sun's energy can be transferred to plants





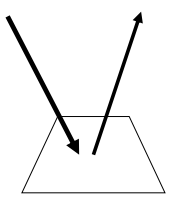
- The Sun's energy (light) is converted into chemical energy (sugar) during a process called photosynthesis.

$6\ CO_2 + 6\ H_2O \longrightarrow C_6H_{12}O_6 + 6\ O_2$

Albedo Effect

- When energy hits a surface it can either be absorbed or reflected
- Albedo is the percentage of light that an object reflects
  - The greater the percentage, the greater the amount of reflection

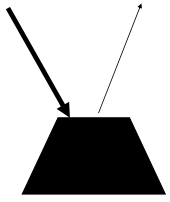
90% Albedo



Most of the energy is reflected

- most of the energy is lost

20% Albedo



Most of the energy is absorbed

- would cause object to heat up

Things with high Albedo
- Snow
- Light colours
- Clouds
- Humidity

Things with low Albedo
- Dirt
- Dark Colours

Energy Moving Through the Ecosystem

- Energy is transferred through the ecosystem through trophic levels (feeding levels)

- 1st trophic level
  - Make their own food from the Sun's energy
  - Also called Autotrophs ('self-feeder') or producers
  - Ex. plants, algae

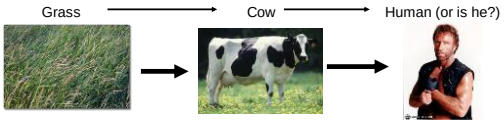
- 2nd trophic level
  - Consumes 1st trophic level
  - Called heterotrophs ('other- feeder)
  - Also known as 1st consumer level
    - Herbivores and ominvores


- 3rd trophic level
  - Consumes 2nd trophic level
  - Also called 2nd consumer level
  - Or 1st carnivore level


- Trophic levels, consumer levels, and carnivore levels continue on sequentially.
- An organism can be at more than one level
  - Ex. A human is at the 2nd trophic level when eating salad and the 3rd trophic level when eating chicken.

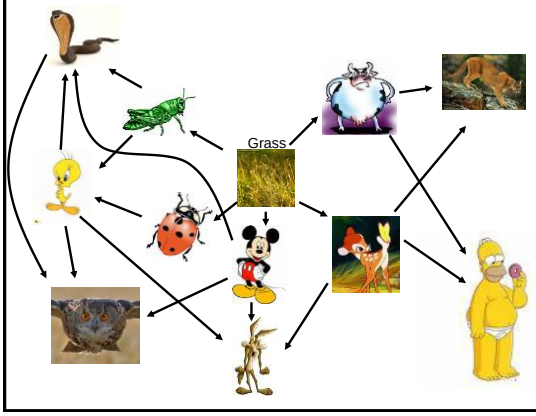
Food Chain

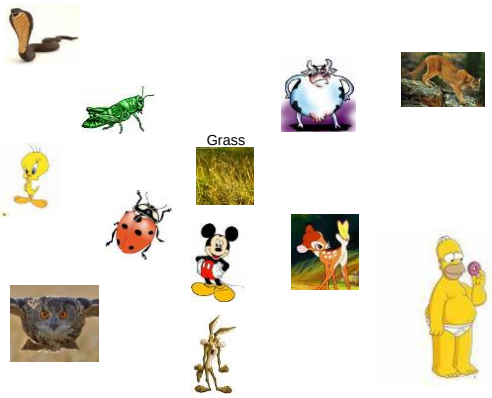
- Food Chain- Step by step sequence linking organisms that feed on each other starting with producers.
  - Shows the movement of energy
  - Decomposers are not included.



Food Web

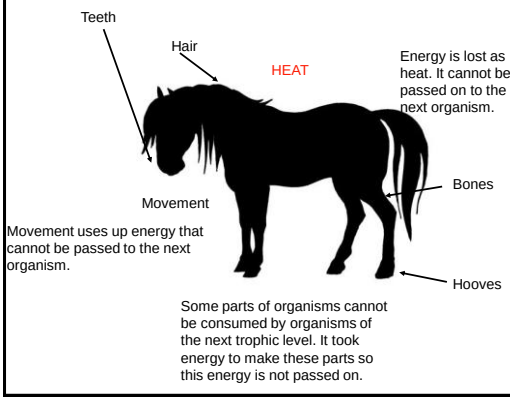
- Food Web- Food chains of an ecosystem combined together in a feeding relationship.
  - Symbolizes the movement of energy in a ecosystem
  - The more intricate the food web is, the more stable the ecosystem is. (Biodiversity)

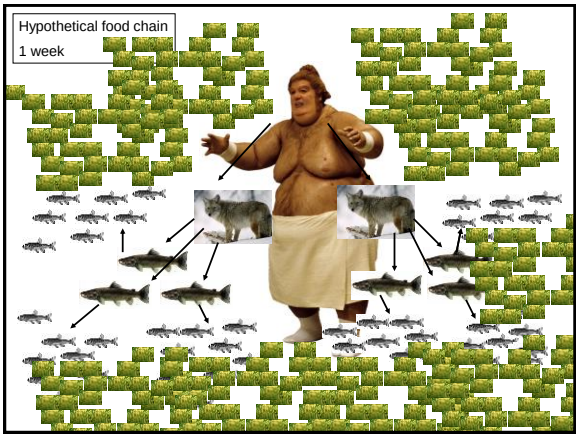




Energy Transfer Limits

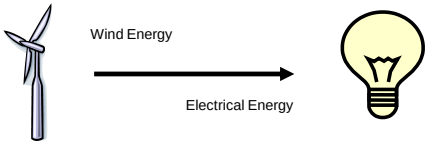
- Not all energy absorbed by one organism can be passed on to the next organism
  - Energy is used up in movement, warmth, inedible material, etc.
  - There is less and less energy available as you move through a food chain.
  - The maximum number of trophic levels possible is about 5.
    - There is just not enough energy for more trophic levels.



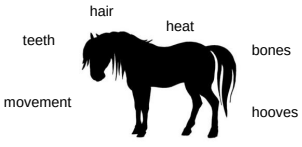


Thermodynamics

- 1st Law of Thermodynamics- Energy cannot be created nor destroyed.
  - It can only be transferred from one form to another



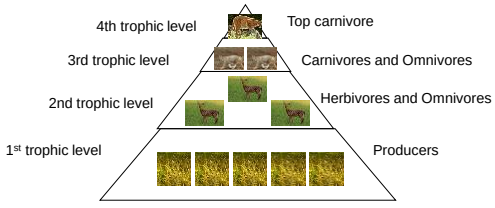
- 2nd Law of Thermodynamics- During any energy transfer, some energy is converted into an unusable form that cannot be passed on.



Pyramids

- An Ecological Pyramid graphically shows the relationship between trophic levels
- Pyramid of energy- Shows the sum of all the energy of all the organisms at each trophic level.
  - Always more energy at the bottom than the top.

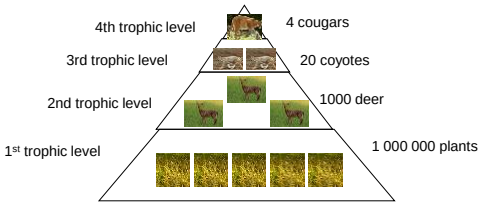
Pyramid of Energy



Pyramid of Numbers

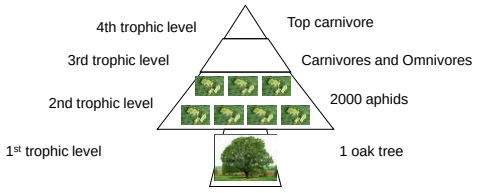
-Shows the number of organisms at each trophic level.

-Typically there are more organisms at lower trophic levels.



Exception to the Pyramid of Numbers

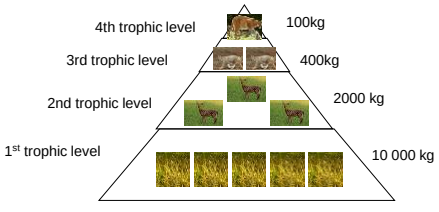
- When a larger organism is fed upon by a smaller organism, the pyramid will look more like a Christmas Tree



Pyramid of Biomass

-Shows the dry-weight (water removed) of all organisms at each trophic level.

-Typically there is more biomass at lower trophic levels.



Roles in the Ecosystem

- Ecological Niche- An organisms 'place' in the ecosystem.
  - Place in the food web, habitat, breeding area, active time of day.

Ex.

Competition in the Ecosystem

- There are two types of competition
- Intraspecies competition- Competition between organisms of the same species.
  - 'intra' – within
  - A good thing
  - Natural selection
  - Survival of the fittest

- Interspecies competition- Competition between organisms of different species.
  - 'Inter'- between
  - Can be a bad thing
  - Both species may be weakened
  - Could cause extirpation or extinction of one or both species.

- Interspecies competition can occur when an exotic species is introduced.
  - Exotic species- New species not native to an ecosystem.
- The exotic species will have to create a niche in its new ecosystem.
- This will put it in competition with other species for their niches.
  - This competition can affect the stability of an ecosystem.

Hawk's eat mice in their ecosystem

There may be a decline in mouse, hawk and snake population

If a type of python is introduced into the ecosystem that eats mice as well, there will be less mice for the hawks to eat.

Cycling of Matter in the Ecosystem

- Matter cannot be created or destroyed.
- Whatever matter exists on Earth now is all the matter that has been on Earth since its creation.
- In order for life to continue, matter must be cycled.
  - All matter in your body is recycled matter.

Carbon Cycle

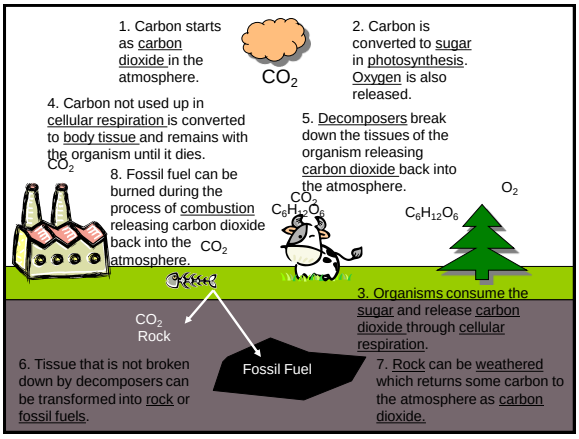
- Carbon is found in all living things
- In the atmosphere, carbon is found as CO_2 (Carbon dioxide)(inorganic)
- CO_2 is changed into sugar (organic) through photosynthesis.
- Sugar can also be converted back into CO_2 through a process called cellular respiration.

$6\ CO_2 + 6\ H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$

Photosynthesis

Cellular Respiration

- Photosynthesis and cellular respiration are <u>complimentary</u>.
  - Exact opposites of one another.



- Combustion-

Fossil Fuel + $6O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ + energy

Carbon Reservoirs

- Carbon can be stored outside the Carbon Cycle in 3 ways.
  - CO_2 in the atmosphere (smallest reservoir)
  - CO_2 stored in the oceans
  - Carbon stored as rock (largest reservoir)

Organic Carbon Reservoirs

- Carbon can also be stored in <u>peat</u>.
  - <u>Peat</u>- Dead plant matter that is not decomposed.
    - Beginning stage of a fossil fuel.

Carbon Cycle

1. Carbon starts as _____ _____in the _____.
2. Carbon is converted to _____ in _____. _____ is also released.
3. Organisms consume the _____ and release _____ through _____.
4. Carbon not used up in _____is converted to _____and remains with the organism until it _____.
5. _____ break down the _____ of the organism releasing _____back into the _____.
6. _____ that is not broken down by _____ can be transformed into _____ or _____.
7. _____ can be _____ which returns some carbon to the atmosphere as _____.
8. _____ can be burned during the process of _____ releasing _____ back into the _____.

Human Effects on the Carbon Cycle

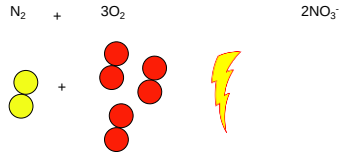
- We are releasing carbon dioxide back into the carbon cycle faster than normal. (Burning of fossil fuels)
- We are removing trees at a greater rate which consumed carbon dioxide from the atmosphere.

The Nitrogen Cycle

- Nitrogen is used in proteins and DNA in your body.
- N_2 gas makes up 79% of the atmosphere.
- Most organisms cannot use N_2 gas.
  - It must be converted to NO_3^- (nitrate) to be useable by organisms.

N_2 Gas Conversion

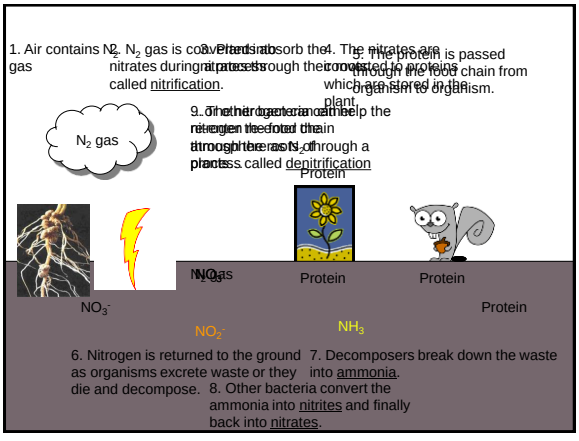
- There are 2 ways to convert N_2 gas into nitrates.
  1. Lightning- nitrogen gas combines with oxygen in the air to form nitrates.
     - It dissolves in the rain and is absorbed into the soil.



2. Nitrogen fixing bacteria- take N_2 gas and convert into nitrates.

   -nitrogen fixing bacteria can be found in soil and nodules of legumes.

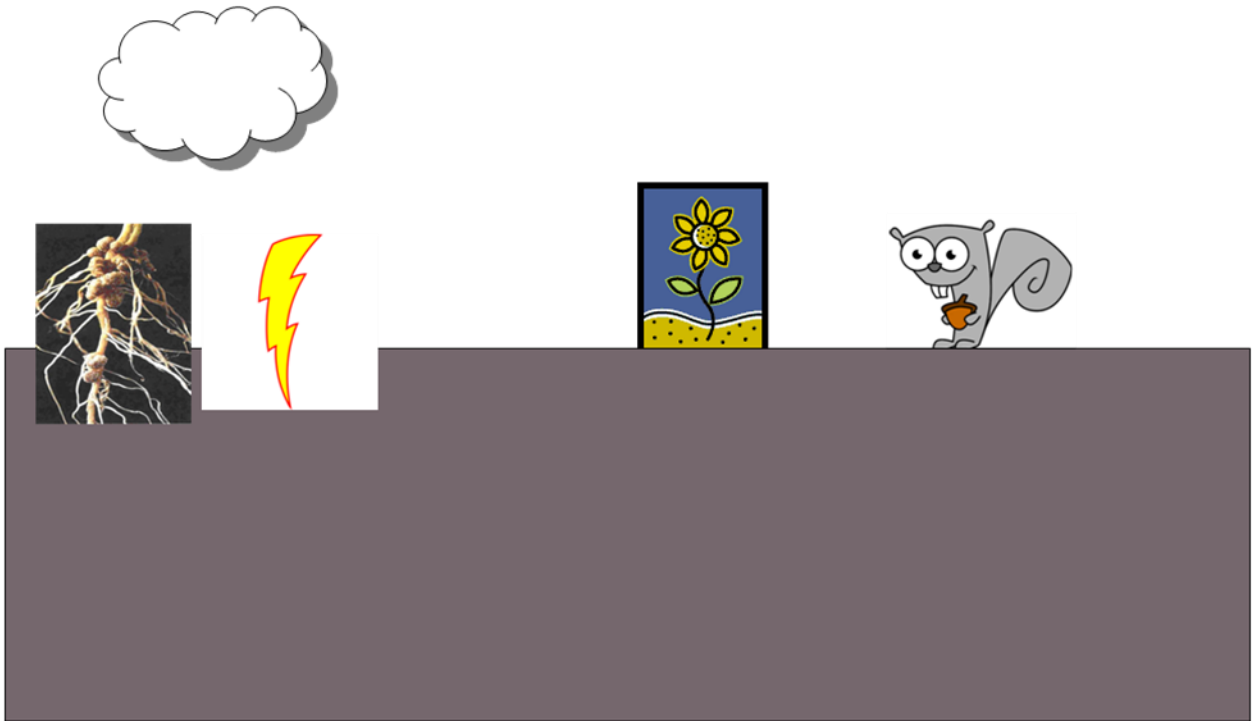
   -legume- peas, soybeans, alfalfa, clover, etc.



Phosphorous Cycle

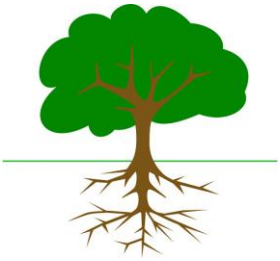
- Phosphorous is used in DNA and cell membranes.
- Phosphorous is usually stored and absorbed as a phosphate (PO_4^{-3}).
- The phosphorous cycle as two distinct parts.
  - The short cycle- phosphorous stays in the food web.
  - The long cycle- Phosphorous is converted to rock and stored for a long time.

Nitrogen Cycle

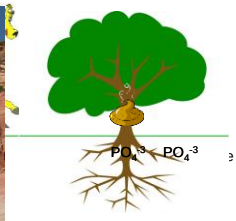


1. _____ contains _____ gas
2. _____ gas is converted into _____ during a process called _____
3. _____ absorb the _____ through their _____.
4. The _____ are converted to _____ which are stored in the _____.
5. The _____ is passed through the _____ from organism to organism.
6. _____ is returned to the ground as organisms _____ waste or they _____ and _____
7. _____ break down the waste into _____.
8. Other _____ convert the _____ into _____ and finally back into _____.
9. The _____ can either re-enter the _____ through the _____ of _____ … or other _____ can help the _____ re-enter the _____ as _____ gas through a process called _____

Phosphorous Cycle



1. _____ are stored in _____ and _____ for millions of years.
2. Over time, _____, _____, _____ and _____ will _____(break down) the _____ and _____ and release the _____ into _____, _____ and _____.
3. The _____ can now be absorbed by _____ and passed through the _____.
4. _____ can be returned into the _____ as _____remove animal _____…or the _____ can be transformed into _____ and _____ where they will sit for millions of years.



…or the phosphates can be transformed into rock and fossils where they will sit for millions of years.

Problems with cycling of matter

- Bioamplification- a process that results in increasing concentrations of a toxin in the bodies of consumers at each succeeding trophic level.
  - The buildup of poison as you move through a food chain.

Pesticide

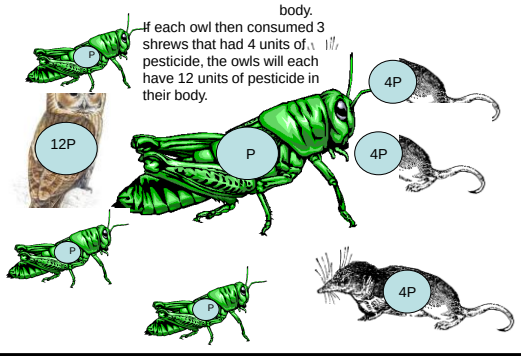
- Pesticide- a chemical designed to kill organisms considered to be inconvenient to humans.
  - 1st generation pesticide- naturally occurring pesticides. (citronella, etc.)
  - 2nd generation pesticide- synthetically produced pesticide. (DEET, etc.)

- Synthetic pesticides do not break down when digested.
- It is stored in fatty tissues and gets passed on from trophic level to trophic level.
- Since organisms from higher trophic level eat several organisms from lower trophic levels, they consume more poison

Suppose each grasshopper received 1 unit (P) of pesticide.

If each shrew consumes 4 grasshoppers, the shrew will now have 4 units of pesticide in its body.

If each owl then consumed 3 shrews that had 4 units of pesticide, the owls will each have 12 units of pesticide in their body.



Improvements

- Newer chemicals dissolve in water and therefore pass through organisms more easily, slowing down the effects of bioamplification.
  - But since the chemicals break down more easily, you may have to apply the pesticide more often.

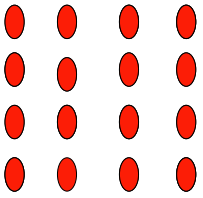
Chemical Resistance

- If an organism contains a gene that is resistant to a chemical, they will survive the application of a pesticide.
- Their chemically resistant genes will be passed on to the next generation.
- More and more organisms will become resistant to a particular pesticide.
  - Options to get rid of the pest is to increase the chemicals strength (concentration) or change chemicals all together.

After a few generations, all the organisms have become resistant to the pesticide.

= Regular organism

= Resistant organism



When pesticide is applied, all the regular organism will die.

When the resistant organism reproduces, some of the offspring will be resistant and some will not be resistant.

Populations

- Populations change when individuals are added or removed.
  - There are only 4 ways for this to happen.
    - Natality (births) (+)
    - Mortalilty (deaths) (-)
    - Immigration (moving in) (+)
    - Emigration (moving out) (-)

Pop. Growth = (births + immigration) – (deaths + emigration)

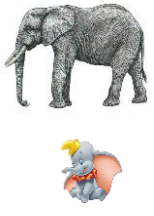
- Dynamic equilibrium- when all 4 population growth factors balance out over a long period.
  - Pop. Growth = ~0
- 2 types of populations
  - Open population- all 4 population growth factors are available.
  - Closed population- only natality and mortality affect population growth.
    - Lab setting, earth.

Population Limits

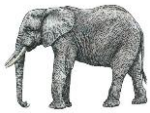
- A population can only grow to a certain point depending on its environment.
- Biotic potential- the maximum number of offspring that a species could produce with unlimited resources.

Factors Determining Biotic Potential

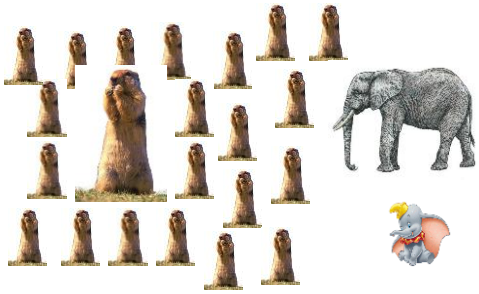
1. Maximum number of offspring per birth.
   - The more babies born at once, the greater the biotic potential



2. Number of offspring that reach reproductive age.
   – How many babies will survive to reach reproductive age.


3. Number of times a species reproduces each year.
   – The more times a species can reproduce a year, the faster its population can grow.

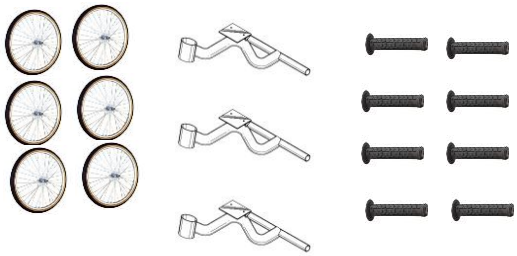


4. Age of sexual maturity and number of years you can reproduce.
   – The sooner children can have babies the greater the population can grow.
   – The longer you can produce children, the greater the population can get.

Limiting Factor

- Limiting factor- a resource in short supply will limit the population size.
  – Resources needed- Light, temperature, chemicals, food, water.

How many Tricycles can you make?



How many Tricycles can you make?

2 | 3 | 4

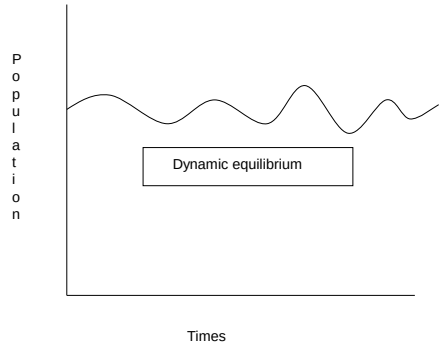
In this case, which tricycle part is the limiting factor for the number of tricycles that can be made?

The tires are the limiting factor

What may the limiting factor for human population growth?

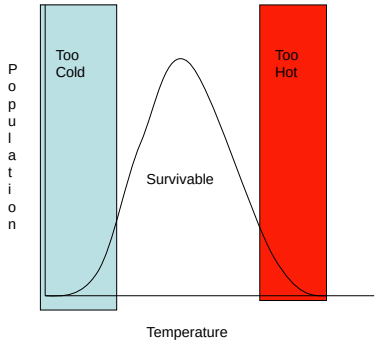
Carrying Capacity

- The maximum number of individuals of a species that can be supported indefinitely by an ecosystem.
  - The carrying capacity is determined by the available resources.
- Populations tend towards stability
  - They do not want to change
  - They achieve dynamic equilibrium.
    - Overall population growth is = 0



Limits of Tolerance

- Law of the Minimum- The nutrient in least supply is the one that limits growth.
- Law of Tolerance- An organism can survive (tolerate) a certain range of abiotic factors; above and below the limit, the organism cannot survive



Density Dependent and Independent Factors

- Density- The number of organisms in an area.
  - High density = lots of organisms in an area
  - Low Density = few organisms in an area.

- Density independent factors- factors that will affect a population regardless of population density.
  - Ex. fire, flood, volcanic eruption

- Density dependent factors- factors that affect a population because of the density of population.
  - Ex. food, water, disease

Canadian Biomes

- Biome- collection of ecosystems that have a similar climate and major vegetation.
- Canada has 4 major biomes.

Tundra

- Lots of water is held in the layer of soil above the permafrost.
- Slow cycling of matter due to the cold.
- Limited plant life limits the number of consumer

Boreal Forest

- South of Tundra
- Makes up 80% of Forest area in Canada.
- Mainly coniferous trees because of short growing season and acidic soil.
- Branches and needles create constant shade on forest floor.
  - Limited food supply on forest floor

Temperate Deciduous Forest

- South of Boreal Forest.
- Richer soil due to higher temperature.
  - More decomposition of fallen leaves.
  - Sun reaches forest floor.
  - Ideal environment for insects, reptiles, amphibians, mammals, etc.

Grassland

- South of Boreal Forest, same latitude as Deciduous Forest.
- Same abiotic conditions as the deciduous forest except for moisture.
  - Lots of fires prevent large tree growth.
- Black earth of the grasslands is the most fertile soil on earth.
- Low biodiversity because of the openness.

Biogeography

- Different plants grow in different parts of the world due to the climate
  - Usually abiotic factors

- Types of plants grow according to their latitude and altitude.
- The further away from the equator you move, the air becomes cooler and the growing season becomes shorter.
  - Broad-leafed evergreen trees near the equator
  - Thin needled evergreen trees far from the equator.

- The higher up in altitude you move, the cooler the air temperature and less air there is.
  - Larger trees at low altitude.
  - Smaller trees at higher altitude.